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Published in:
International Journal of Clinical Practice

DOI (link to publication from Publisher):
10.1111/ijcp.13280

Publication date:
2019

Document Version
Accepted author manuscript, peer reviewed version

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Article type : Original Paper

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Time trends in use of the $CHADS_2$ and CHA_2DS_2VASc scores, and the geographical and specialty uptake of these scores from a popular online clinical decision tool and medical reference

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Abstract

Background

The impact of the utilisation of such e-health approaches, including mHealth (use of mobile phones and other wireless technology in the delivery of medical care) assessments of health parameters, or the use of decision aids and online risk calculators over time have not been previously described. The objective of this analysis is to assess the time trends in use of the $CHADS_2$ and CHA_2DS_2VASc scores in e-health, and the geographical and specialty uptake of these scores, using data gleaned from a popular online clinical decision tool and medical reference, MDCalc. We hypothesised that the change in use of the scores would reflect the changes in guidelines and trends in clinical practice.

Results

The CHA_2DS_2VASc score was the 20th most popular calculator in 2012, rising to the 2nd most popular calculator in 2018; the $CHADS_2$ score showed the converse, dropping from no. 3 to no. 22.

Use of the CHA_2DS_2VASc scores particularly increased in the United States, Canada and Australia over time while the United Kingdom experienced a greater traffic share in 2015. The majority users of the $CHADS_2$ and CHA_2DS_2VASc scores were primary care physicians, with cardiologists being in the minority; the proportion of cardiologists was greater outside USA, compared to within USA.

Conclusion

Over time, use of the CHA_2DS_2VASc score increased, while use of the $CHADS_2$ score decreased. The change in uptake could partly be related to introduction of guidelines recommending the use of the CHA_2DS_2VASc score for stroke risk stratification.

Key words Stroke risk, CHA_2DS_2VASc, $CHADS_2$ Score, risk calculator, clinical decision tool, e-health, mhealth

What is already known about this topic?

- Medical decision making is increasingly influenced by electronic-health (e-health) information technology approaches, including mHealth assessments of health parameters, or the use of decision aids and online risk calculators.

What does this article add?

- Over time, use of the CHA_2DS_2VASc score increased, while use of the $CHADS_2$ score decreased. The change in uptake could partly be related to introduction of guidelines recommending the use of the CHA_2DS_2VASc score for stroke risk stratification.

1. Introduction

Medical decision making is increasingly influenced by electronic-health (e-health) information technology approaches, including mHealth assessments of health parameters, or the use of decision aids and online risk calculators(1). The impact of ultilisation of such e-health techniques over time have not been previously described.

Take the case of the management of atrial fibrillation (AF), the most common heart rhythm disorder, whereby stroke prevention is the cornerstone of management(2). AF is commonly managed by general practitioners and non-cardiologists, and over the last two decades we have seen the introduction of stroke risk stratification schemes, such as the $CHADS_2$ score (June 2001) and more latterly, the CHA_2DS_2VASc score (September 2009), to aid decision-making for thromboprophylaxis(2). Most guidelines initially recommended the use of the $CHADS_2$ score but with increasing data on improved refinement of stroke risk assessment, beginning in 2012 the CHA_2DS_2VASc score became more recognized by medical societies and is now recommended in most guidelines from the United States, Europe, and Asia (3-5).

The objective of this analysis is to assess the time trends in use of the $CHADS_2$ and

CHA_2DS_2VASc scores in e-health, and the geographical and specialty uptake of these scores, using data gleaned from a popular online clinical decision tool and medical reference, MDCalc. We hypothesised that the change in use of the scores would reflect the changes in guidelines and trends in clinical practice.

2. Methods

2.1. Study Design

A retrospective study was carried out using usage data from a popular online clinical decision tool and medical reference, MDCalc. Authors of this manuscript include a founder and part owner of MDCalc, as well as employees and advisors of MDCalc. The latter was first introduced in 2005, and is the first natural search result to appear for most terms used to find $CHADS_2$ and CHA_2DS_2VASc scores. Data analyzed were from MDCalc's web and app usage and registration databases, provided by MD Aware LLC. The authors hypothesised that analysis of such data can measure and possibly predict the update of clinical tools over time. The study investigated data obtained using Google Analytics on the CHA_2DS_2-VASc Score for Atrial Fibrillation Stroke Risk (CHA_2DS_2-VASc Score), the $CHADS_2$ Score for Atrial Fibrillation Stroke Risk ($CHADS_2$ Score), and a normalization group of scores from January 1, 2012 to April 30, 2018.

2.2. Analytics Platform

Data were collected for visits to the mdcalc.com website and MDCalc iOS and Android apps in one month intervals using the statistics tool Google Analytics. The relevant Google Analytics metrics used in this study include:

User

This Google Analytics metrics attempts to count how many unique individuals access MDCalc in a given time. Specifically, it's typically tracked using an "electronic cookie" that's managed by Google Analytics.[1]

Geographical Data

Google Analytics provides a number of geographical dimensions, such as City, Country, Continent, and more. The values for these dimensions are automatically derived from the IP address of the computer or mobile device used.[2]

2.3. Data Collection and Processing

In this study, data were collected for Users, specific MDCalc pages (calculators) visited, geographical data (country) in the Google Analytics servers and, for registered Users, registration data were collected in the MDCalc User Database. Anonymized data were exported from Google Analytics and the MDCalc User Database as .csv files and compiled in Microsoft Excel for further analysis and visualization.

User Adoption

The data were examined in two groups, (i) Users who visited the CHA_2DS_2-VASc Score, and (ii) Users who visited the $CHADS_2$ Score. The data for both groups were normalized as explained in the following section. MDCalc did not specifically promote either $CHADS_2$ or CHA_2DS_2-VASc Scores during the study period.

[1] https://support.google.com/analytics/answer/2992042?hl=en&ref_topic=2709827

[2] https://support.google.com/analytics/answer/6160484?hl=en

Normalization

Medical calculator and reference popularity has risen dramatically over the last decade as technology is increasingly adopted in the clinician workflow. In addition, with time, physicians have become more tech savvy and more evidence based, both of which have led to a large increase in the usage of EBM electronic medical references such as MDCalc. Therefore, in order to capture the relative use and popularity of specific scores, data must be normalized to account for these trends. The approach to normalization also took into account that sometimes specific calculators are replaced by newer calculators – for reference in the last four years, MDCalc has gone from 80 to 370 calculators with over 600 scores in the pipeline. The Normalization Group was chosen by identifying scores that ranked, in order of most visits, in the top 25 from January 1, 2012 to February 28, 2012 *that also* ranked in the top 50 from January 1, 2018 to February 28, as described in Table 1. This approach attempted to capture the the overall trend in increased MDCalc use, while removing specific calculators which may have been popular in 2012 but had a large drop in use by 2018, and therefore not be useful in normalization. Of note, only 2 calculators of the "top 25" in 2012 fell off the "top 50" by 2018 – the other 23 are listed in Table 1. The aforementioned time periods were chosen for two reasons: first, both scores were available on MDCalc during these periods, second, the 2012 ESCG Guidelines for the management of AF (the first major guideline formally recommending the CHA_2DS_2-VASc Score) had not yet been published.

Per Country Adoption

In order to evaluate when the CHA_2DS_2-Vasc Score and the $CHADS_2$ Score were adopted in specific countries, per country User data from Google Analytics for March of 2012, 2015, and 2018 was normalized by the average of the Normalization Group in each country and was mapped (Figure 3) with a constant maximum and minimum. MDCalc has been available globally, in English, since 2005.

Per Specialty Adoption

User specialty data are available on Google Analytics for logged in Users, a requirement for the iOS and Android app. For Users who visited the CHA_2DS_2-Vasc Score, User specialties, as reported by Users at registration, were collected for both the U.S. and Ex-U.S. (Figure 4) and compared with relative specialty representation amongst iOS and Android app Users in the MDCalc User Database.

3. Results

From January 1, 2012 to February 28, 2012 the CHA_2DS_2-VASc Score was ranked the 20th most popular calculator on MDCalc and the second most popular calculator from January 1, 2018 to February 28, 2018. For those same time periods, the $CHADS_2$ Score ranked no. 3 and no. 22, respectively – the Normalization Group average rank was 12.3 and 21.7, respectively.

3.1. General Usage of CHA_2DS_2-VASc Score

The CHA_2DS_2-VASC Score had a peak of 109,347 Users in February 2018, surpassing the $CHADS_2$ Score monthly Users from December 2012 to April 2018, with the exception of December 2013 (Figure 1). A seasonal variation was observed around the November and December holidays and during the month of June. In 2018 the average number of monthly users for the CHA_2DS_2-VASC Score was 2.96 times greater and the $CHADS_2$ Score was .076 times greater than the top 25 scores ($p<0.0001$).

The normalized (2012) data, fig. 2, reveals that the CHA_2DS_2-VASC Score had two intervals of peak growth from September 1, 2012 to January 31, 2013 and February 1, 2014 to October 31, 2014. There is be both a decrease in Users who used the CHA_2DS_2-VASC Score, 17.3%, and an increase, 85.9%, in Users who used the $CHADS_2$ Score in February and March, 2017.

We noted an inconsistent drop in CHA_2DS_2-VASc Score use starting around February 2017, with a correlated increase in $CHADS_2$ use, which seemed to return to trend line after April 2017 (Figure 1). Analyzing the search terms used for users landing on such pages for these same months, a large number of users landing on the $CHADS_2$ page had actually searched for "CHA_2DS_2-VASC Score" (Figure 2, Panel 2). This would suggest this Feb-April 2017 change in usage was more likely due to Google search result changes, not in purposeful change in use by users: i.e. users mistakenly clicking on the $CHADS_2$ page as it temporarily appeared high up in their "CHA_2DS_2-VASc Score" search.

3.2. Per Country Adoption of CHA_2DS_2-VASc Score

User data per country, normalized to 2012, are shown in a series of geographical heat maps (Figure 3) at three time intervals, March 2012, 2015 and 2018.

The CHA_2DS_2-VASc Score normalized (2012), (Figure 3, Panel 1) showed an increase in relative Users in the United States, Canada and Australia over time while the United Kingdom experienced a greater traffic share in 2015 than 2018, with the least traffic share in 2012. Conversely, the $CHADS_2$ Score (Figure 3, Panel 2) experienced a decrease in relative Users in the United States, Australia and the United Kingdom over time while Canada experienced a greater traffic share in 2015 than 2018, with the least traffic share in 2012. The sharp increase in normalized use of the CHA_2DS_2-VASc Score in UK from 2012 to 2015, with a *relative* decrease in 2018, may represent how MDCalc was relatively new to the U.K. in those years, and that the CHA_2DS_2-VASc Score led in terms of UK's physicians' use of MDCalc scores in 2015 – perhaps due to the 2014 NICE guidelines which included the score. This limited analysis was meant only to screen for broad country specific trends. An interesting further area of research may include a more detailed analysis of per country adoption, including data at more time intervals, details on when guidelines and other relevant local authorities promoted scores, and potential normalizations tailored to each country.

3.3. Per Specialty Adoption of CHA_2DS_2-VASc and $CHADS_2$ Scores

The CHA_2DS_2-VASc Score and $CHADS_2$ Scores were used most frequently by primary care providers and then cardiologists, both in the United States and outside of the United States (Figure 4, Panel 1). Taking into consideration that some specialties are larger than others, the percentage of specialists who use CHA_2DS_2-VASc and $CHADS_2$ Scores on MDCalc were graphed in Figure 4, Panel 2, showing that more cardiologists who use MDCalc use those scores, particularly the CHA_2DS_2-VASc, were outside of the United States.

4. Discussion

In this analysis, our principal findings are as follows: (i) the CHA_2DS_2VASc score was the 20th most popular calculator in 2012, and rose to become the 2nd most popular calculator; the $CHADS_2$ Score showed the converse, dropping from no. 3 to no. 22; (ii) Use of the CHA_2DS_2VASc scores increased in the United States, Canada and Australia over time while the United Kingdom experienced a greater traffic share in 2015; and (iii) the majority users of the $CHADS_2$ and CHA_2DS_2VASc scores were primary care physicians, with cardiologists being in the minority. Interestingly, the proportion of cardiologists was greater outside USA, compared to within USA.

This is the first systematic analysis of trends in e-health usage of two stroke risk scores for stroke prevention in AF, the $CHADS_2$ and CHA_2DS_2VASc scores. The increasing use of CHA_2DS_2VASc score in the USA is clearly evident from the marked change in heat maps (Figure 3), especially following the publication of the ACC/AHA/HRS guidelines in 2014(3). The increase in the UK in 2015, may reflect the new NICE guidelines, which recommended use of the CHA_2DS_2VASc score(6). Guideline change per se need not necessarily translate to more e-health use, as the Canadian guidelines do not recommend the CHA_2DS_2VASc score, but CHADS65 or the CCS algorithm(7). Also, the Asia-Pacific guidelines recommend the CHA_2DS_2VASc score but MDCalc uptake was limited in the Asia-Pacific region, which could partly reflect accessibility(5).

In a recent survey of European arrhythmia practitioners conducted by the European Heart Rhythm Association (EHRA), 98.3% used the CHA_2DS_2VASc score for stroke risk stratification; the remainder (1.7%) used the older $CHADS_2$ score(8). This is perhaps unsurprising given the European guidelines recommend use of the CHA_2DS_2VASc score(4).

There are many interesting findings, some of which could be investigated further and potentially acted upon. For example, how quickly do physicians adopt new, better clinical scores after (a) the evidence shows they may be superior, and (b) after medical societies and guidelines promote their use? Has such adoption delay shortened over the years, and if so, what factors have shortened it. How effective is acceptance by medical societies and guidelines to driving adoption? Can electronic medical references also help speed along adoption, and by how much? Does this vary across physician populations (by age, geography, or specialty)?

More specific to medical references, can changes in their design, or even in Google search results, effect how physicians practice (see the "bump" in $CHADS_2$ use in early 2017, likely due to temporary google search changes). What can be implemented to mediate this? Finally, how do clinical outcomes with specific patient populations in specific countries correlate with the use of clinical scores in those countries? Such analysis may help quantify the relative benefit of a new score over old standard of care practice, which could have an impact not only on how physicians apply the scores, but also on how researchers spend their time, what grant administrators decide to fund to have the most clinical impact, and how payers and providers decide to value the proper use of clinical scores.

Limitations

Using cookies allows analytics.js to identify unique users across browsing sessions, but it cannot identify unique users across different browsers or devices.[3] The specialty data is only app data (which were missing from March 3/2016 to 2/2017) although overall trends

for specialty use should be a reasonable representation of users. In some countries, the lack of data does not necessarily mean no usage, but lack of access may be a factor.

Conclusion

Over time, use of the CHA_2DS_2VASc score increased, while use of the $CHADS_2$ score decreased. The change in uptake could partly be related to introduction of guidelines recommending the use of the CHA_2DS_2VASc score for stroke risk stratification.

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Table 1

Normalization Group

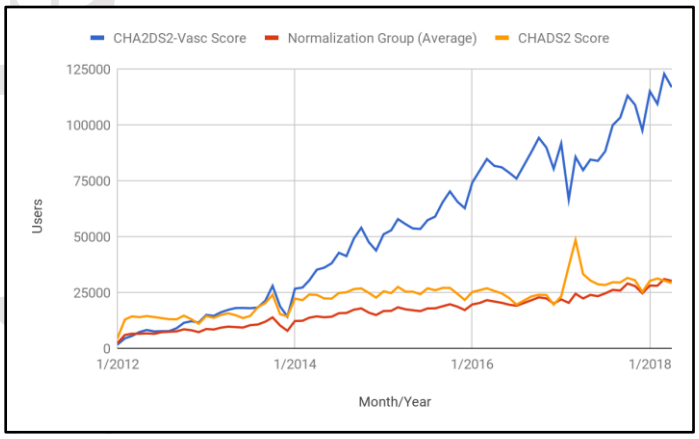
	Score	**Jan-Feb 2012 Rank***	**Jan-Feb 2018 Rank***
1	Creatinine Clearance (Cockcroft-Gault Equation)	1	1
2	Wells' Criteria for Pulmonary Embolism	2	3
3	$CHADS_2$ Score for Atrial Fibrillation Stroke Risk	3	22
4	Calcium Correction for Hypoalbuminemia	4	5
5	Fractional Excretion of Sodium (FENa)	5	8
6	TIMI Risk Score for UA/NSTEMI	6	25
7	Corrected QT Interval (QTc)	7	11
8	Framingham Coronary Heart Disease Risk Score	8	23
9	MELD Score (Model For End-Stage Liver Disease) (12 and older)	9	7

10	A-a O_2 Gradient	10	48
11	Fractional Excretion of Urea (FEUrea)	11	38
12	APACHE II Score	12	44
13	Wells' Criteria for DVT	13	19
14	Parkland Formula for Burns	14	43
15	MDRD GFR Equation	15	18
16	Maintenance Fluids Calculations	16	20
17	Absolute Neutrophil Count (ANC)	17	26
18	PERC Rule for Pulmonary Embolism	18	14
19	CHA_2DS_2-VASc Score for Atrial Fibrillation Stroke Risk	20	2
20	Anion Gap	21	30
21	$ABCD^2$ Score for TIA	22	36
22	Maddrey's Discriminant Function for Alcoholic Hepatitis	23	45
23	HAS-BLED Score for Major Bleeding Risk	25	12

*Rank was based on visits

Fig. 1

Panel 1: Absolute Users per month, not normalized



Panel 2: Users per month, normalized (2012)

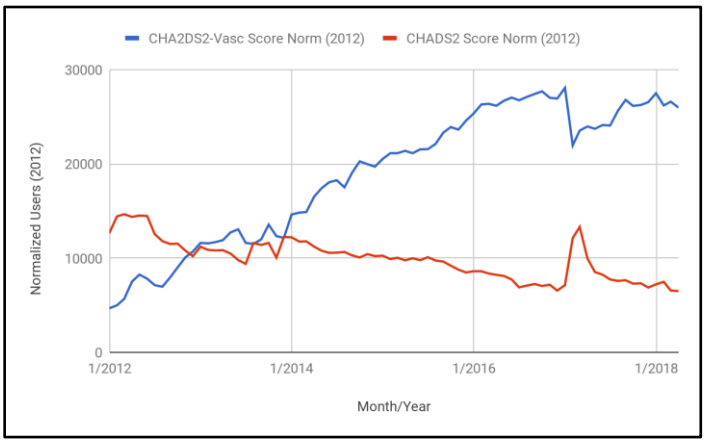
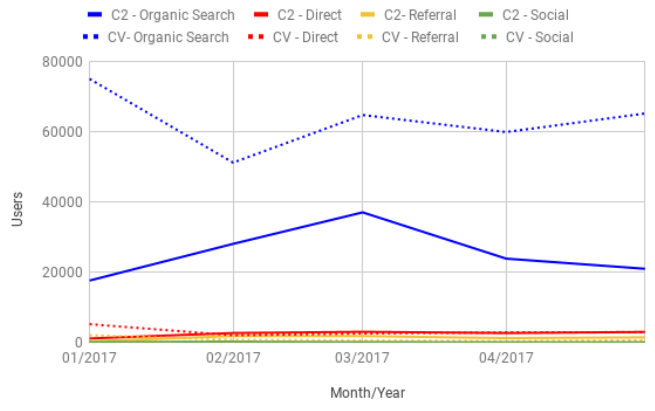


Fig. 2

Panel 1: Landing page traffic source



Panel 2: $CHADS_2$ landing page – organic search terms

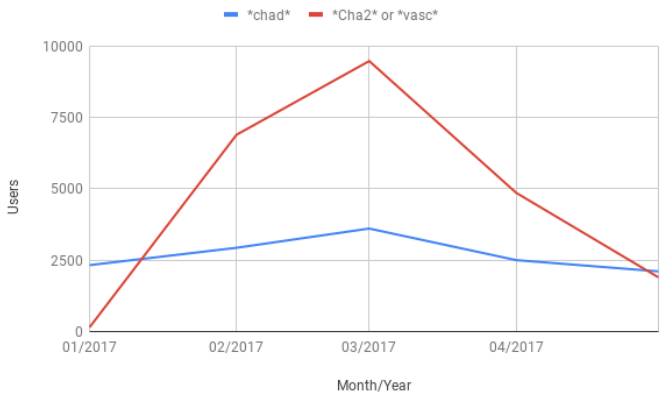


Fig. 3.

Panel 1: CHA_2DS_2-VASc Score, normalized (2012), Users per country

A) March 2012	B) March 2015	C) March 2018
		

Panel 2: $CHADS_2$ Score, normalized (2012), Users per country

A) March 2012	B) March 2015	C) March 2018
		

Panel 3: CHA_2DS_2-VASc Score and $CHADS_2$ Score, per country, 2012, 2015 & 2018.

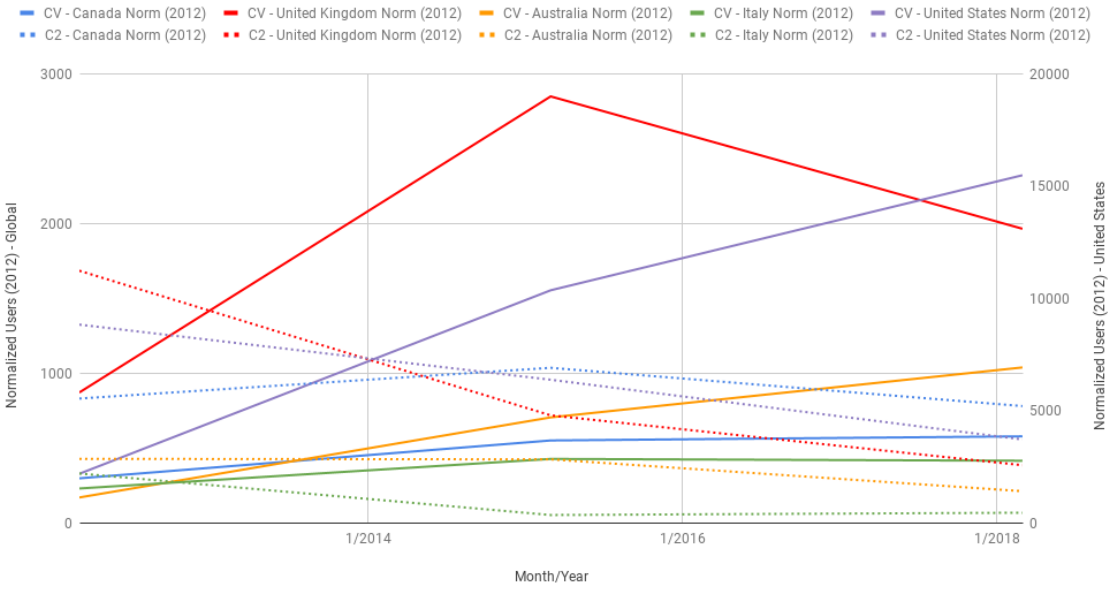
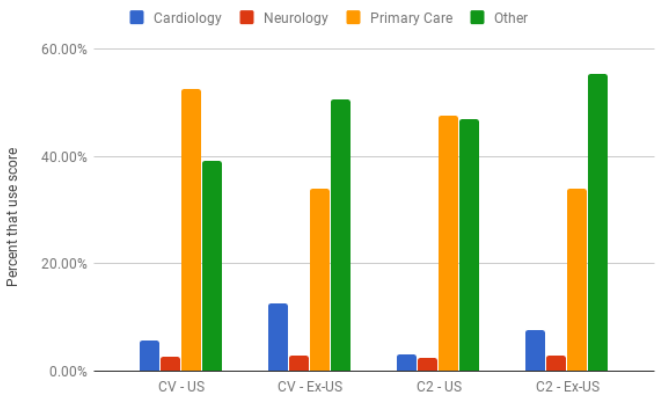


Fig. 4

Panel 1: Portion of total CHA_2DS_2-Vasc Usage by Specialist (2018).



Panel 2: Portion of each specialty group that used CHA_2DS_2-Vasc in the past month (2018).